

GREENLAND SEA CURRENTS

TECHNICAL REPORT

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University of Washington  
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Effective Date: 1 June 1971  
Expiration Date: 31 May 1973

Contract Amount (as modified): \$244,500

Contract N000 14-67-A-0103-0023, Project NR 307-342

Sponsored by: Advanced Research Projects Agency  
ARPA Order No. 1783

Scientific Officer: Director, Arctic Programs  
Earth Sciences Division  
Office of Naval Research  
Department of the Navy  
800 North Quincy Street  
Arlington, Virginia 22217

Report Date: 1 June 1972

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## Technical Report Summary

### *Introduction*

The Greenland Sea holds a position of unique importance and interest among all the Arctic seas. There are two essentially different reasons for this.

One, the northern portion constitutes the major connection of the Arctic Basin with the rest of the world ocean, both in terms of depth and cross-sectional area, and in terms of the actual flow of water (cf. Coachman and Aagaard, in press). No satisfactory heat and mass budgets for the Arctic can be constructed without a considerable improvement in our knowledge of the heat and mass transports through the Greenland Sea. There is evidence that the present budgets may have underestimated the actual transports through the Greenland-Spitsbergen passage by one-half order of magnitude, and that the internal transports in the Greenland Sea have been underestimated by a full order (Aagaard and Coachman, 1968a). It is certainly clear that the dominant barotropicity of the area makes it impossible to substitute dynamic calculations based on temperature and salinity measurements for direct current observations (Aagaard and Coachman, 1968b).

Two, the Greenland Sea (and the Norwegian and Iceland seas, together with which it forms an intricately combined system) is a large, deep, partially ice-covered sea; it is one of the northern hemisphere's primary heat exchangers (cf., e.g., Fletcher, 1965), and as such of vital importance in the total global energy budget; it routinely permits navigation farther north than anywhere else in the world; it exhibits a circulation of the same order of magnitude as the Gulf Stream system. In all these ways it is an area of great importance and interest in its own right.

### *The present problem*

The single most important line of investigation to further our environmental understanding of the area must be direct current measurements. It seems clear that the logical first area of concentration should be the Greenland-Spitsbergen passage, through which the exchange with the Arctic Ocean occurs. Eventually the current measurements must extend throughout the year, for our flow observations in the East Greenland Current (Aagaard, 1968), our wind stress calculations (Aagaard, 1970), and analytical work presently in progress on the thermohaline circulation, all imply substantial seasonal differences in the circulation. However, the practical obstacles are formidable, for during winter (1) the area is largely ice-covered; (2) there is total darkness for about four months; (3) bad weather and severe icing conditions are common. Furthermore, logistics and navigation are always problematic in this part of the world.

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## Methods

In view of the above it was decided to deploy moored current meters, anchored for one year beneath the reach of the drifting ice. The successful deployment and retrieval of such instruments would not only avoid the problems of winter field operations, but would also represent a quantum jump advance both scientifically and technologically. That is, it would provide the urgently needed oceanographic data, and it would also be the first successful year-long current meter deployment anywhere in the world.

A total of six current meters were moored in the Greenland-Spitsbergen passage in September 1971. The mooring positions are shown in Fig. 1. They are designed to be recovered by acoustic activation of the explosive release mechanism which frees the mooring from its anchor. The subsurface float then rises to the surface, and the equipment is taken aboard the recovery vessel. The details of the instruments and methods were described in the Technical Report of 30 December 1971.

Preparations for retrieval of the moorings have proceeded apace. We have obtained five weeks time aboard the largest and newest of the Icelandic research vessels, the *Bjarni Saemundsson*, during August-September 1972. She is equipped with a large array of sophisticated sonar and should thus maximize our opportunity for locating and recovering the moorings.

To fully utilize the opportunity afforded by the availability of the *Bjarni Saemundsson*, we shall, subsequent to mooring retrieval, be continuing the direct measurement of currents, this time using drogues. There are three reasons for the deployment of drogues, rather than moored current meters. One, before deploying further moored arrays of current meters in the Greenland Sea it behoves us to evaluate our first mooring attempts; this, of course, cannot be done until after summer 1972. Two, the use of drogues is a highly reliable form of current measurement, so that our results are in a sense guaranteed. Three, we have had three years of experience in the deep western Bering Sea developing the techniques involved, and we feel that we have achieved a fairly high degree of competency. The method employs active radar transponders on the drogue buoys and satellite navigation aboard ship. The details are given in Appendix A and Fig. 2.

## Technical Results

We feel the problems of mooring design and assembly to have been solved satisfactorily, and that the deployed systems represent good and practical Arctic deep-sea current meter arrays. The actual handling of the equipment at sea and its successful deployment is to large degree a matter of good seamanship; the latter is a prime requirement in Arctic operations of this sort.

Two essential technical requirements stand out. One is the need for very accurate navigation in order to position the buoys during deployment; in the Greenland Sea this will in practice mean satellite navigation. The other requirement is high-quality directional sonar to precisely locate the buoys during recovery.

### *Department of Defense implications*

Recovery of the current meters with their data would permit a substantial increase in our environmental understanding of the strategically and tactically important Greenland Sea. Such understanding would seem particularly essential to problems of submarine operations.

There is in addition a host of Department of Defense sponsored research in the Arctic with climatological aspects. An improved knowledge of the heat and mass exchange through the Greenland-Spitsbergen passage bears directly on these aspects.

Finally, we believe that a modest addition has been made to the fund of Arctic buoy technology and operational experience.

### *Implications for further research*

This summer we shall in part be concentrating the drogue measurements in the central Greenland Sea, where analytic studies presently in progress indicate converging subsurface flow of Atlantic water. This flow appears to be thermally forced and to be of a seasonal nature. Its presence, manifested by a subsurface temperature and salinity maximum, affects the acoustic properties of the upper layers and would presumably bear on submarine operation problems. The matter would seem important from that viewpoint alone.

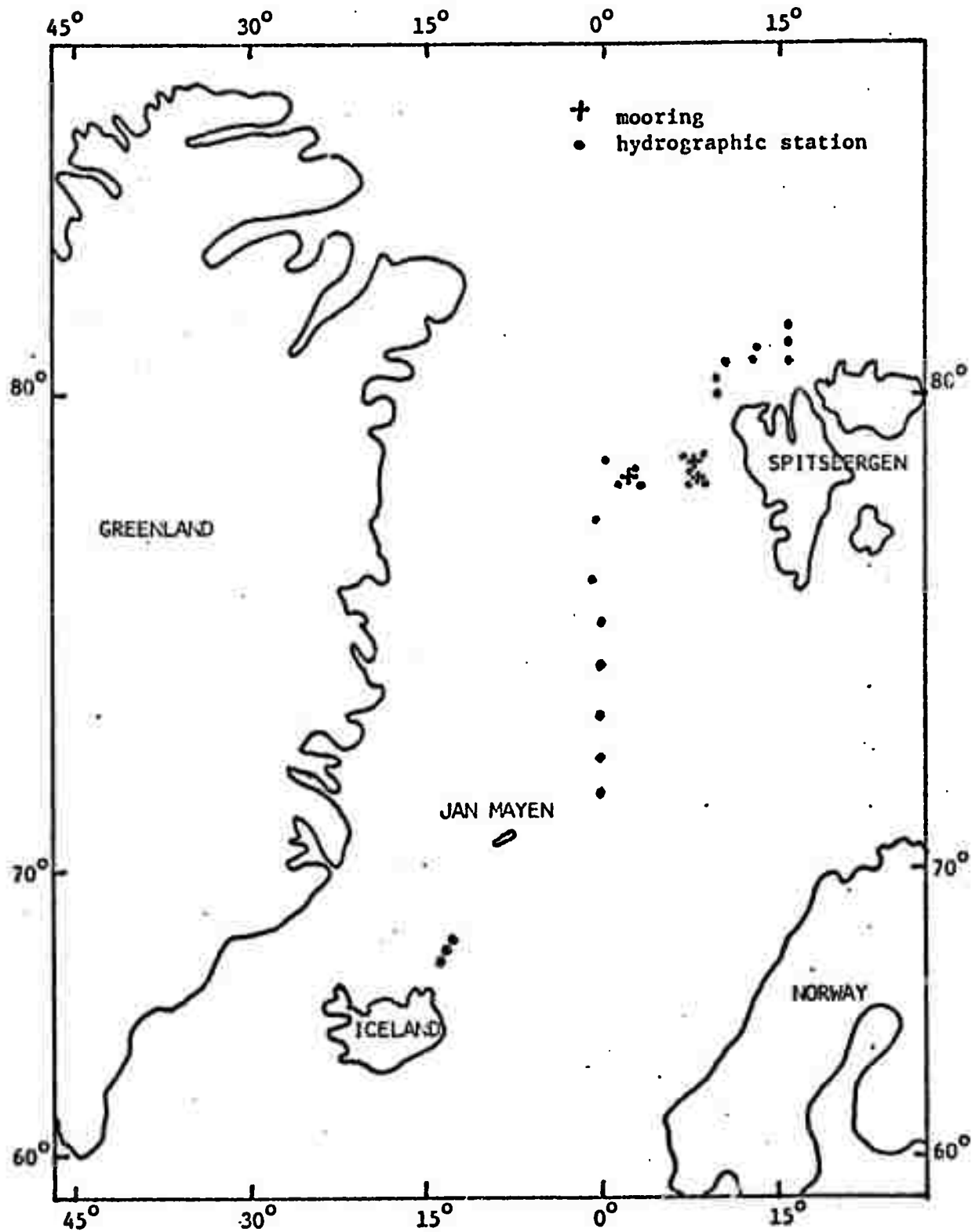


FIGURE 1. MOORING AND HYDROGRAPHIC STATION LOCATIONS

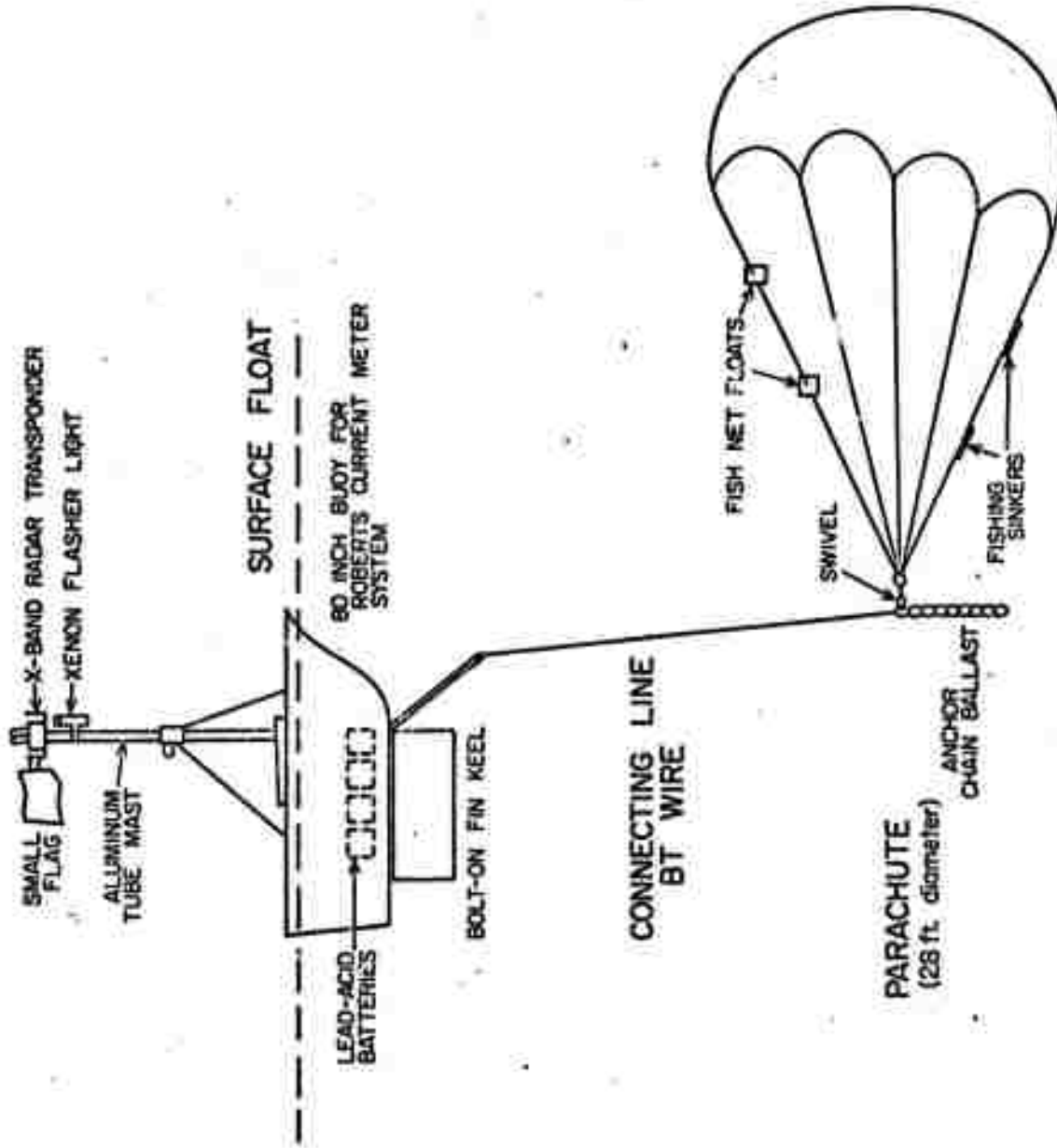


FIGURE 2. THE DROGUE SYSTEM

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## Appendix A

### *Current Measurements Using Drogues*

Drogues are Lagrangian current followers, assumed to behave like a neutrally buoyant parcel of water. We shall be using parachutes as the actual drogue. The parachute will be attached to a surface float, the position of which is tracked and assumed to represent the trajectory of the subsurface water. Our experience in the Bering Sea indicates that meaningful current measurements can be made at depths of 1000 m or more in this manner (Hughes, Coachman and Aagaard, in press).

The drogue system will use as a surface float a 2 m Roberts current meter buoy modified to support a 3 m aluminum mast and a 30 kg keel. Atop the mast will be mounted an active radar transponder, rather than a conventional passive radar reflector. This can be expected to increase the maximum radar range to about 10 nautical miles, compared with 2-3 nautical miles using reflectors (Hughes, Coachman and Aagaard, in press). Furthermore, the achievable range using reflectors depends much more critically on sea state than does the range using transponders, due to the difficulty in differentiating the reflector image from the sea return on the radar scope. With a transponder system, the radar set aboard ship can be tuned to maximize the transponder signal while minimizing the sea return. Additionally, the transponder can be coded to transmit a multiple delayed signal which is easily distinguishable from the sea return.

The transponders operate in the X-band and will be compatible with the Decca radar aboard the *Bjarni Saemundsson*. They have a polarized antenna, a 50-125 watt peak power, and employ a 24-30 volt DC power supply. They return to a stand-by condition if not interrogated within about one minute, thus conserving the power supply. The power will be provided by four heavy-duty 12 volt automobile batteries mounted in racks installed low within the floats to thus also serve as ballast.

The drogues are parachutes of approximately <sup>8.5</sup>~~15~~ m in diameter, suspended from the float by galvanized bathythermograph wire of 2.4 mm diameter. Weights of 70-90 kg will be used to keep the wire nearly vertical. To assist in keeping the parachute shrouds from entangling, as well as in maintaining parachute orientation, small fishing sinkers will be attached to the lower shrouds, styrofoam fish net floats to the upper shrouds, and the entire parachute assembly connected to the BT wire through swivels.

In order to determine the drift of the drogues in geographical coordinates, the track of the ship (which serves as a baseline relative to which the drogues are tracked by radar) must be determined. This will be done by maintaining a nearly constant ship's velocity; in fair weather by simply drifting, or if a sea is running, by maintaining steerage way windward or leeward. The ship's track will be determined by single-



frequency satellite navigator, which in the Greenland Sea can be expected to provide a good fix about once each hour.

Several buoys can readily be tracked at one time. When a drift has been completed (taking on the order of 1-2 days), the floats are retrieved, new drogues fitted, and the system redeployed after recharging the batteries.

The drogues will be deployed in pairs, with one drogue set shallow and one deep. Such placement will provide a measure of the mean vertical shear, to be compared with the geostrophic shear calculated from concurrent synoptic hydrographic information. The latter will be obtained by hydrographic casts made around the drogue trajectory.